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VACUUM TUG MILLING-EXTRUSION MOLDING MACHINE  
[SHINKU TSUCHIREN OSHIDASHI SEIKEIKI]

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## Specification

## 1. Title of the Invention

Vacuum Tug Milling-Extrusion Molding Machine

## 2. Claims

(1) A vacuum tug milling-extrusion molding machine, characterized in that it is equipped with a tug milling part in which a screw is rotated and driven in a cylinder; several rotary disks whose both side surfaces are tapered surfaces, are installed coaxially to said screw in part of the screw, valleys having opposite inclined surfaces are installed in gaps between the tapered surfaces of said rotary disks of the screw on the inner surface of said cylinder, and a kneading material with a semi-flow shape supplied to said cylinder is kneaded by receiving shear and compression actions between said tapered surfaces and the inclined surfaces in a process for transferring the kneading material in the axial direction of the cylinder; an extrusion molding part in which the material kneaded in the tug milling part is transferred in the axial direction of a cylinder by a screw which is rotated and driven in the cylinder, extruded from a mouth piece for molding installed at the tip of the cylinder, and extrusion-molded; and a vacuum deaeration part

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<sup>1</sup> Numbers in the margin indicate pagination in the foreign text.

arranged between these tug milling part and extrusion molding part.

2. The vacuum tug milling-extrusion molding machine as cited in Claim 1, characterized in that at least one set of spiral feed grooves for feeding a kneading material is installed over said several rotary disks in the screw of said tug milling part.

### 3. Detailed Description of the Invention

(Technical Field)

The present invention relates to a vacuum tug milling-extrusion molding machine. More specifically, the present invention relates to a vacuum tug milling-extrusion molding machine that carries out tug-milling for kneading a ceramic kneading material with a semi-flow state by applying a shear action and a compression action and extrusion-molding by one unit of apparatus, when ceramic thin plates, etc., are extrusion-molded.

(Prior Art)

In general, in case high-quality ceramic thin plates, etc., are extrusion-molded, a ceramic raw material, which is formed by mixing and kneading fine ceramic powder, binder, molding aid, and water in advance at a prescribed ratio, is kneaded and deaerated by a tug mill such as vacuum tug mill as shown in

Figure 1 to form an unbaked ceramic. This unbaked ceramic is molded into a thin plate shape by a vacuum extrusion molding machine of a one-stage

/2

type or two-stage type as shown in Figure 2.

The tug mill shown in Figure 1 is a so-called auger type that kneads a ceramic raw material by rotating and driving a screw having a spiral blade in a cylinder, and this rug mill is a two-stage type in which a vacuum chamber 3 is arranged between an upper-stage kneading part 1 and a lower-stage kneading part 2. In the tug mill of Figure 1, the ceramic raw material (not shown in the figure) charged into a raw material charge opening 4 is supplied to the upper-stage kneading part 1 in which one or two screws 6 are arranged in a cylinder 5, kneaded by receiving a shear action and a compression action, transferred to the vacuum chamber 3, and deaerated. The ceramic raw material deaerated is further supplied to the lower-stage kneading part 2 in which one or two screws 8 are arranged in a cylinder 7 from the vacuum chamber 3 similarly to the upper-stage kneading part 1, kneaded by receiving the shear action and the compression action, and discharged as an unbaked ceramic from a discharge opening 9.

The unbaked ceramic (not shown in the figure) obtained as mentioned above is molded into a thin plate shape by the two-stage vacuum extrusion molding machine shown in Figure 2.

The vacuum extrusion molding machine shown in Figure 2 has almost the same constitution as that of the tug mill of Figure 1. A vacuum chamber 13 is installed between an upper-stage extrusion part 11 and a lower-stage extrusion part 12, and the unbaked ceramic (not shown in the figure) charged into the unbaked ceramic charge opening 14 is supplied to the upper-stage extrusion part in which one or two screws 16 are arranged in a cylinder 15, extruded to the vacuum chamber 13, and deaerated. The unbaked ceramic deaerated is compressed by a roller 17 installed at the bottom of the vacuum chamber 13, supplied to the lower-stage kneading part 12 in which one screw 19 is arranged in a cylinder 18, molded into a thin plate shape from a mouth piece 20, and extruded.

However, in the tug mill described in Figure 1 for forming an unbaked ceramic from a ceramic raw material, as the screw 6 of the upper-stage kneading part 1 and the screw 8 of the lower-stage kneading part 2, screws having one set, two sets, or three sets of screws in a shaft with a circular cross section have been used (two sets of screws are shown in Figure 1). In this tug mill, the space between the cylinder 5 and the screw 6 or between the cylinder 7 and the screw 8 is increased, thus being

unable to apply sufficient shear action and compression action to the unbaked ceramic. In order to obtain an unbaked ceramic in which ceramic powder, binder, molding aid, and water were uniformly dispersed, it was necessary to repeat the kneading operation many times. For this reason, the tug milling process and the molding process were respectively independent separate processes, and labors were respectively required for each process, raising the molding cost of a thin plate ceramic.

(Purpose of the Invention)

The present invention considers the aforementioned situation, and its purpose is to obtain a vacuum tug milling-extrusion molding machine, in which a kneading effect is raised by applying large shear action and compression action to a kneading material and a tug milling process and an extrusion molding process are carried out by one apparatus, by devising the shape of a cylinder for kneading the kneading material by applying shear and compression actions in a process for feeding the kneading material in the axial direction of the cylinder and screws which are rotated and driven in the cylinder.

(Constitution of the Invention)

In other words, the present invention provides a vacuum tug milling-extrusion molding machine characterized in that it is equipped with a tug milling part in which a screw is rotated and driven in a cylinder, several rotary disks whose

both side surfaces are tapered surfaces are installed coaxially to the aforementioned screw in part of the screw, valleys having opposite inclined surfaces are installed in gaps between the tapered surfaces of the aforementioned rotary disks of the screw on the inner surface of the aforementioned cylinder, and a kneading material with a semi-flow shape supplied to the aforementioned cylinder is kneaded by receiving shear and compression actions between the aforementioned tapered surfaces and the inclined surfaces in a process for transferring the kneading material in the axial direction of the cylinder; an extrusion molding part in which the material kneaded in the tug milling part is transferred in the axial direction of a cylinder by a screw which is rotated and driven in the cylinder, extruded from a mouth piece for molding installed at the tip of the cylinder, and extrusion-molded; and a vacuum deaeration part arranged between these tug milling part and extrusion molding part.

#### (Application Examples)

Next, application examples of the present invention will be described with reference to the attached figures.

Figure 3 shows the tug milling-extrusion molding machine of the present invention in which a tug mill and a vacuum extrusion molding machine are integrated.

In Figure 3, 31 is a kneading part, 32 is an extrusion

molding part, and 33 is a vacuum chamber. The kneading part 31 is arranged at the upper step, and the extrusion molding part 32 is arranged at the lower step.

The aforementioned kneading part 31 consists of one or two cylinders 34 and screws 35 which will be mentioned later, and the screws 35 are rotated and driven by a screw driving motor (not shown in the figure).

The extrusion molding 32 consists of cylinder 35, screw 36, and mouth piece part 37 for molding, and the screw 36 is rotated by a screw driving motor (not shown in the figure).

The vacuum chamber 33 is arranged between the kneading part 31 and the extrusion molding part 32. The air in the vacuum chamber 33 is drawn by a vacuum pump not shown in the figure.

In the tug milling-extrusion molding machine with the aforementioned constitution, the cylinder 34 and the screw 35 of the kneading part 31 are formed as shown in Figure 4 from its halfway position to the front end.

In other words, on the outer side surface of the part from a halfway position of the aforementioned screw 35 to the front end, rotary disks 38, 38, etc., with an abacus bead shape whose both side surfaces  $F_1$  and  $F_2$  are tapered surfaces are formed at a nearly equal interval coaxially to the aforementioned screw 35.

On the other hand, at the aforementioned cylinder 34, valleys 39, 39, etc., having inclined opposite surfaces  $S_1$  and  $S_2$ , for example, are formed in gaps  $g$  of 1-3 mm between the respective tapered surfaces  $F_1$  and  $F_2$  of the aforementioned rotary disks 38, 38, etc.

With the aforementioned constitution, a ceramic material, where ceramic powder, binder, molding aid, and water are premixed, charged into a raw material charge opening 40 of the kneading part of the tug milling-extrusion molding machine of Figure 3 is transferred toward the tip of the aforementioned screw 35 in the axial direction of the cylinder 34 by screws formed from the rear end of the screw 35 of the kneading part 31 to its halfway position. With this transfer, if the aforementioned ceramic raw material arrives at the part shown in Figure 4, in which the rotary disks 38, 38, etc., of the screw 35 are formed, the aforementioned ceramic raw material is transferred as indicated by an arrow toward the vacuum chamber 33 (see Figure 3) through the gaps  $g$  between the respective tapered surfaces  $F_1$  and  $F_2$  of the rotary disks 38, 38, etc., and the respective inclined surfaces  $S_1$  and  $S_2$  of the valleys 39, 39, etc., on the inner surface of the cylinder 34. In this process, the aforementioned ceramic raw material is sufficiently mixed by receiving a powerful shear action by the respective tapered surfaces  $F_1$  and  $F_2$  of the rotary disks 38, 38, etc., which rotate

oppositely to each inclined surface  $S_1$  and  $S_2$  of the valleys 39, 39, etc., on the inner surface of the cylinder 34, and receiving a powerful compression action during the transfer in the small gaps  $g$  and transferred to the vacuum chamber 33.

In the transfer process of the aforementioned kneading part 31, the ceramic raw material, as mentioned above, is changed to an unbaked ceramic with few foams and a high degree of kneading, in which ceramic powder, binder, molding aid, and water are uniformly dispersed, by receiving powerful shear action and compression action.

Therefore, this unbaked ceramic is supplied to the extrusion molding part 32 through the vacuum chamber 33 and molded into a sheet-shaped ceramic similarly to the vacuum extrusion molding machine of Figure 2.

In the part in which the rotary disks 38, 38, etc., of the screw 35 of the aforementioned kneading part 31 are formed, as shown in Figure 5, spiral feed grooves 41 for feeding the kneading material may also be installed by intersecting with these rotary disks 38, 38, etc. In this manner, the transfer of the ceramic raw material in the part in which the rotary disks 38, 38, etc., of the screw part 35 are formed is made easy, and the shear action, which is received by the ceramic raw material in the gaps between the upper ends of side walls 41a and 41a of the aforementioned spiral feed grooves 41 and the respective

inclined surfaces  $S_1$  and  $S_2$  of the valleys 39, 39, etc., of the cylinder 34, can also be raised.

Figure 6 is a cross section showing a ceramic in which the molded product of the ceramic raw material obtained by using the vacuum tug milling-extrusion molding machine of the aforementioned application example is baked. Figure 6(b) is a cross section showing a ceramic in which the ceramic raw material kneaded by the tug mill of Figure 1 is molded by the vacuum extrusion molding machine of Figure 2 and baked.

As seen from the comparison of Figures 6(a) and 6(b), in case the vacuum tug milling-extrusion molding machine of the present invention is employed, a ceramic with small holes is obtained. In the figures, a is a hole, and b is a ceramic.

Here, as the aforementioned spiral feed grooves 41,

/4

several sets of spiral feed grooves may also be formed.

In addition, in the aforementioned application example, the kneading part 31 may also be a biaxial type, and its number of stage may be two stages or three stages or more.

Figure 7 shows an example in which the kneading part is a two-stage type. In other words, a second kneading part 31' is arranged at the rear step of the first kneading part 31. This second kneading part 31' consists of a cylinder 34' and a screw

35', and a vacuum chamber 33' is arranged between the second kneading part and the extrusion molding part 32.

(Effect of the Invention)

As mentioned above in detail, obviously, according to the present invention, since rotary disks with an abacus bead shape having tapered surfaces are formed in part of a screw, which is rotated and driven in a cylinder, and an opposite tug milling part is installed in small gaps with the inclined surfaces of valleys formed on the inner surface of the cylinder, a kneading material receives large shear action and compression action between the tapered surfaces of the screw and the inclined surfaces of the valley on the inner surface of the cylinder, raising the degree of kneading. Thereby, the kneading material can be kneaded and extrusion-molded by one unit of apparatus, thus being able to reduce labors in molding a thin plate ceramic, etc.

In addition, since feed screws for feeding the kneading material are formed by intersecting with the rotary disks with an abacus bead shape opposite to the inclined surfaces of the valleys on the inner surface of the cylinder formed in part of the screw, which is rotated and driven in the cylinder, the transfer speed of the kneading material in the part in which the rotary disks of the screw are formed, so that the kneading

efficiency of the kneading material is high and the degree of kneading can also be raised.

#### 4. Brief Description of the Figures

Figure 1 is an illustrative diagram showing a conventional tug mill. Figure 2 is an illustrative diagram showing a vacuum extrusion molding machine. Figure 3 is an illustrative diagram showing the vacuum tug milling-extrusion molding machine to which the present invention has been applied. Figures 4 and 5 are respectively illustrative diagrams showing two application examples of the main parts of a kneading part of a tug mill part of the vacuum tug milling-extrusion molding machine of Figure 3. Figure 6 is a cross section showing ceramics. Figure 6(a) is a cross section showing a ceramic in which a ceramic molded product obtained by using the vacuum tug milling-extrusion molding machine of the present invention is baked, and Figure 6(b) is a cross section showing a ceramic in which a ceramic molded product obtained by the tug mill of Figure 1 and the vacuum extrusion molding machine of Figure 2 is baked. Figure 7 is an illustrative diagram showing another application example of the vacuum tug milling-extrusion molding machine to which the present invention has been applied.

31 Kneading Part

32 Extrusion Molding Part

33 Vacuum Chamber

- 34     Cylinder
- 35     Screw
- 37     Mouth Piece For Molding
- 38     Rotary Disk
- 39     Valley
- 41     Spiral Feed Groove
- $F_1, F_2$      Tapered Surfaces
- $S_1, S_2$      Inclined Surfaces

/5

Figure 1

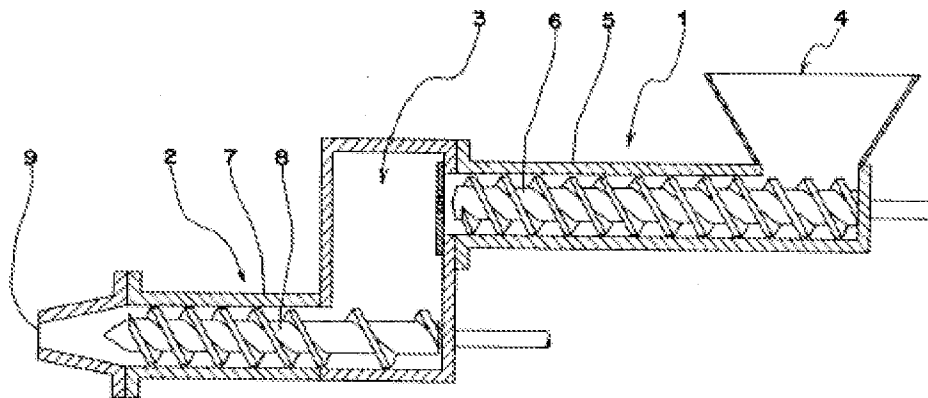


Figure 2

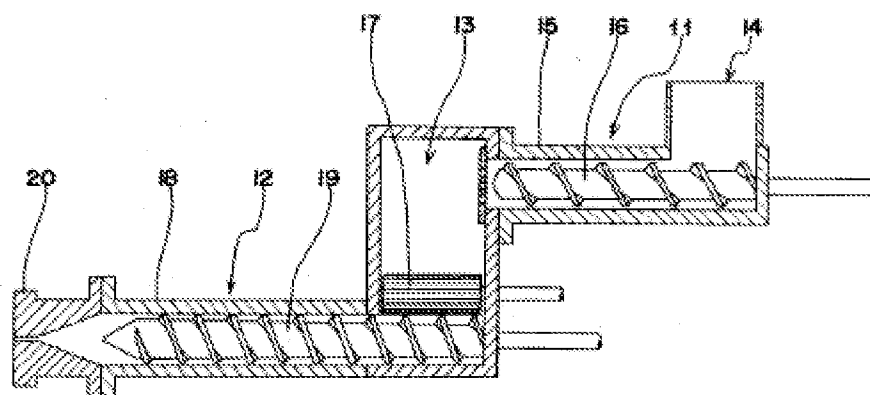


Figure 3

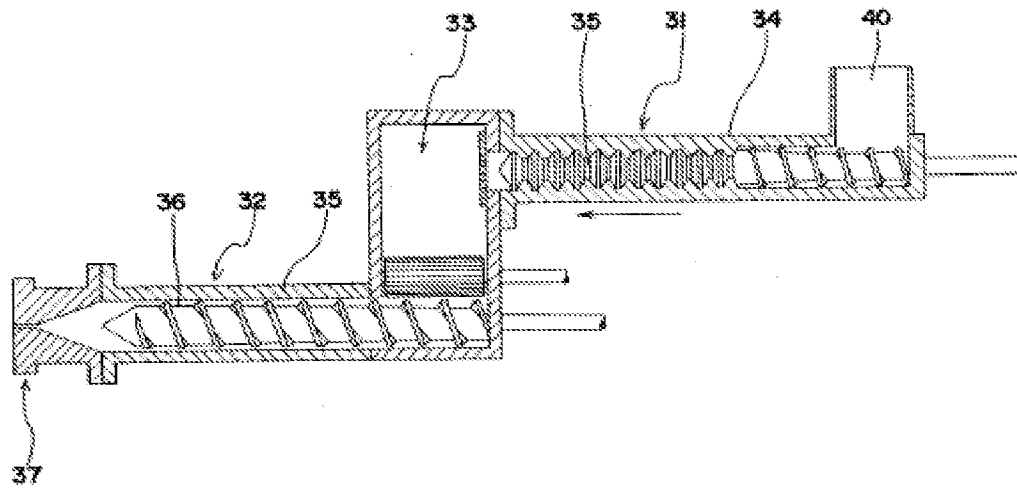


Figure 4

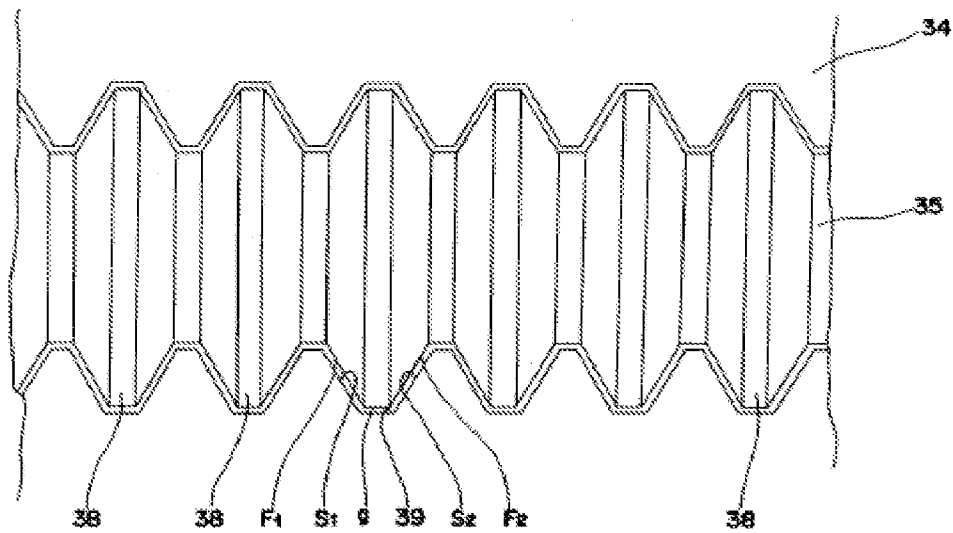


Figure 5

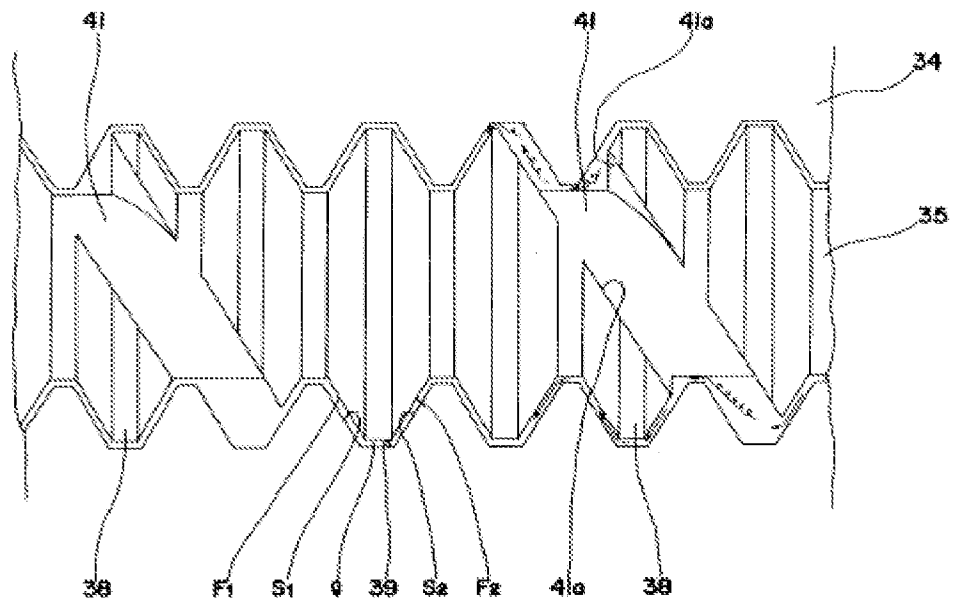


Figure 6

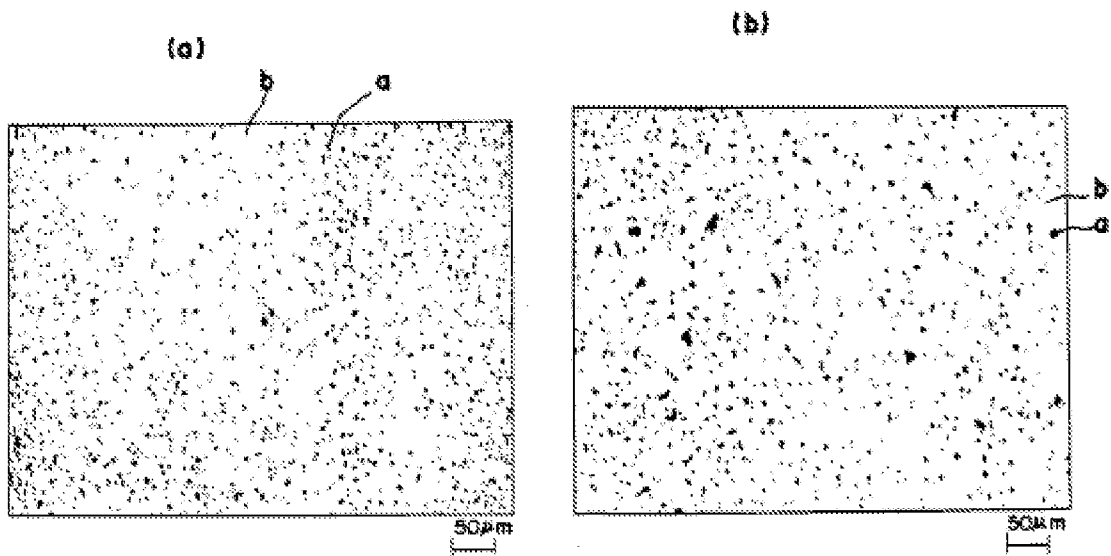


Figure 7

